FiS

PRODUCTS REVIEW

SENSORS AND SYSTEMS TECHNOLOGY

Products range, code numbers

Introduction

Based on its pre-eminent expertise in developing Metal Oxide Semiconductor Gas Sensors, FIS today offers a range of products covering a wide field of applications including:

- Flammable gas detection
- Toxic gas detection
- Indoor air quality controls
- Combustion monitoring/controls
- Cooking controls
- Ventilation controls

The new range of semiconductor gas sensors developed by FIS has achieved an unprecedented reduction in heater power consumption, while preserving the typical features of semiconductor gas sensors such as:

- High reliability
- Long life
- Ease of operation
- Low cost

The basic features and primary applications of FIS products are described on the following pages.

FIS also develops and supplies various products including micro-computers, sensor evaluation units and others such as electrochemical or optical sensors.

FIS always finds the most effective approach to improve gas detection technologies by studying the combination of both sensor technologies and application software.

FIS will continue to develop new sensors to meet the demands of the marketplace.

Products range, code numbers

The range of FIS products and the numbering system of the different models are illustrated here.

Category

S: Semiconductor
L: Lambda (semiconductor)
E: Electrochemical
P: Optical

Type (semiconductor)

B: Bead type
P: Plate type
P3: Plate (3 pins)
P4: Plate (4 pins)
T: Tube type
C: Bulk type

Detection type

Indicated in the Products list

Sub code

This sub code shows the variation of specifications, heater voltage or other conditions

Housing

(P1): Plastic - type 1
(P2): Plastic - type 2
(MC): Mesh Ceramic
(MP): Mesh Plastic
(S): Sintered Metal

Products list

Series			SB series	SP series
Features			• Small heater power consumption (120 mW) • Small size • High sensitivity to flammable gases • Suitable for portable detectors/ battery operated devices	• Reduced heater power consumption using a small gas sensing element • Low heater current • Variation of heater voltage • Wide variation of sensitivity characteristics
Category	**No**	**Detection gas**	**Model (power consumption)**	**Model (power consumption)**
Dual gas	90-	CO and methane	SB-95 (P_H : 120 mW - max.)	
Flammable gases	10-19	General purpose	SB-11A (P_H : 120 mW)	SP-11 (P_H : 400 mW) *
		Methane	SB-12A under development	SP-12A (P_H : 380 mW)
		Propane/butane	SB-15 (P_H : 120 mW)	SP-15A (P_H : 380 mW)
		Hydrogen	SB-19 (P_H : 120 mW)	SP-19 (P_H : 315 mW)
Organic solvents	30-39	General purpose	SB-31 (P_H : 120 mW)	SP-31 (P_H : 315 mW)
		Alcohol	SB-30 (PH : 120 mW)	SP-32 (P_H : 315 mW)
Freon	40-49	R-22	SB-41 (P_H : 120 mW)	SP-41 (P_H : 400 mW)
		R-134a	SB-42 (P_H : 120 mW)	SP-42 (P_H : 400 mW)
Toxic gases	50-59	Carbon monoxide	SB-50 (P_H : 120 mW - max.) SB-500 (P_H : 120 mW - max.)	
		Hydrogen sulphide		SP-51 under study
		Ammonia	SB-53 under study	SP-53 (P_H : 315 mW)
Oxidizing gases	60-69	Ozone		SP-61 under study
		Nitrogen oxides	SB-62 under study	
		Chlorine		SP-65 under study
Cooking controls	MW	General purpose		SP-MW0 (P_H : 400 mW)
		Humidity		SP-MW1 (P_H : 400 mW)
		Alcohol		SP-MW2 under development
		Combustion gas		SP-MW3 under development
Indoor Air Quality controls (air purifiers/ ventilation control systems)	AQ	General purpose	SB-AQ1A (P_H : 120 mW)	SP-AQ1/SP-AQ2 (P_H : 315 mW) SP3-AQ2/SP3-AQ2Y (P_H : 315 mW)
		Cigarette smoke	SB-AQ4 (P_H : 140 mW)	SP-AQ3 (P_H : 315 mW)
		CO_2	SB6-AQ6 under development	SP6-AQ6
Air Damper control in automobiles	AD	Gasoline exhaust gas	SB-AD1 under development	SP-AD1/SP-AD3 under development
		Diesel exhaust gas	SB-AD2 under development	SP-AD2/SP-AD3 under development
Notes			• Using a Dynamic Driving method in the heater operation (pulse voltage), the average heater current can be reduced to 25 mA (example with 5 V)	• Variation of heater voltage is available (Standard: 5 V, option-1:12 V and option-2: 24 V) * Pre-classified version is available for the SP-11

SB series

General

The SB series achieves a dramatic reduction of power consumption in semiconductor gas sensor applications. Compared with conventional gas sensors, only 15% of the power is required to detect methane, propane or other gases. Using this design, increased sensitivity and improved cross sensitivity in flammable gas detection, CO or solvents detection with quick response are achieved.

Structure

The sensing element is a mini bead type semiconductor mainly composed of tin-dioxide (SnO_2). A heater coil and an electrode wire are embedded in the element (Fig 1). The element is installed in the metal housing which uses double stainless steel mesh (100 mesh) in the path of gas flow. The mesh is an anti-explosion feature (Fig 2). The sensor has 3 pins for output signal and heater power supply. The small sensor reduces the required space and the size of products. The SB-50 uses an active charcoal filter as shown in Fig 6.

Operating conditions

Fig 3a and Fig 3b indicate the pin layout and equivalent circuit and Fig 4 shows the standard circuit of the SB series. The applied heater voltage regulates the sensing element temperature to obtain the specific performance of sensors. The change in the sensor resistance is generally obtained as the change of the output voltage across the fixed or variable load resistor (R_L) in series with the sensor resistance (R_S).

Note: In this circuit, Pin No.1 with indication mark (Fig 3a) should be used as a 'common terminal' for both heater voltage (V_H) and circuit voltage (V_C).

Standard operating conditions:

V_C: Less than 5 V DC
R_L: Variable (> 750 Ω)
V_H: 900 mV (SB-11, SB-31, SB-AQ1)
1000 mV (SB-AQ4)
900 mV-3 sec / 200 mV-7 sec (SB-50)

Remarks:

Polarity of V_C and V_H is important.
Apply the V_C and V_H as shown in the circuit diagram.

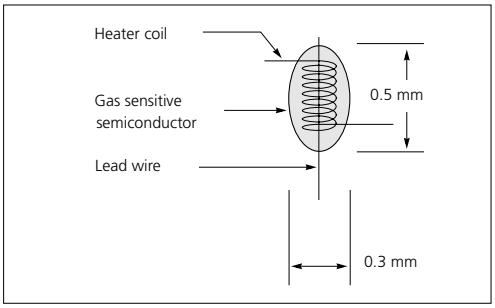


Fig 1. Sensing element

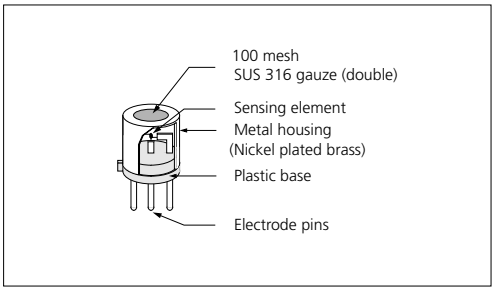


Fig 2. Structure: standard housing

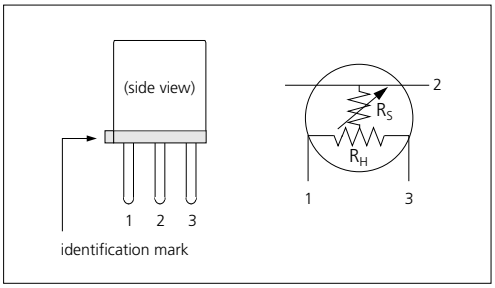


Fig 3a. Pin layout **Fig 3b. Equivalent circuit**

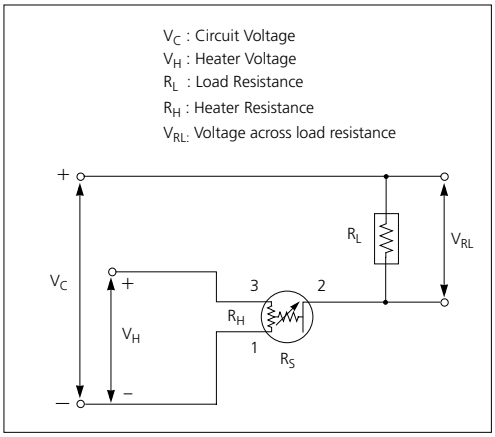


Fig 4. Standard circuit

SB series

Dimensions

Fig 5 shows the dimensions of the SB series (standard housing).

Configurations

Fig 6 shows the configurations of the SB series: standard housing and SB-50 with active charcoal filter.

Other housing

Special sensor housing with an external sintered metal cover is available (example: FIg 7).

Sensitivity characteristics (typical data)

The sensitivity characteristics of semiconductor gas sensors are shown by the relationship between the sensors resistance (R_S) and concentration of gases. The sensor resistance decreases with an increase of the gas concentration based on a logarithmic function (see page 14 for details of sensing mechanism). The standard test conditions of each model are calibrated to meet a typical target gas and concentration. For example, methane 1000 ppm for flammable gas detection, hydrogen 100 ppm for hydrogen detection or ethanol 300 ppm for solvents detection. If different conditions are required for other specific gas detection, please consult FIS.

Figs 8 to 13 on the next page show the typical sensitivity characteristics data of SB series gas sensors. In these diagrams, the sensor resistance change is normalized by the R_S at specific conditions.

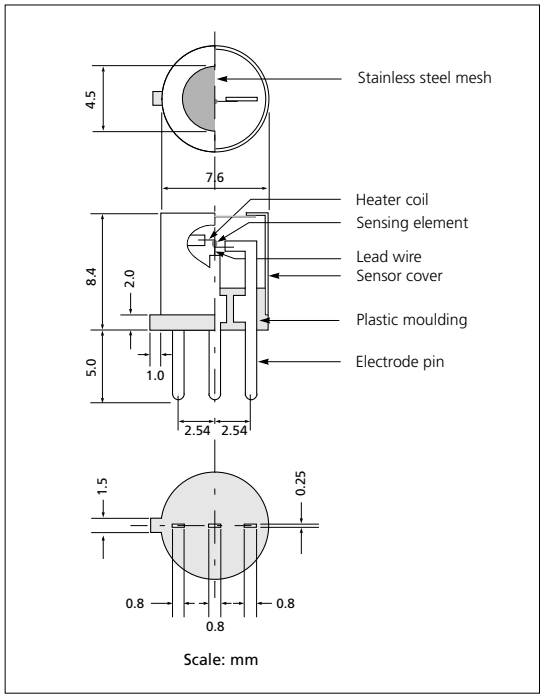


Fig 5. Dimensions: standard housing

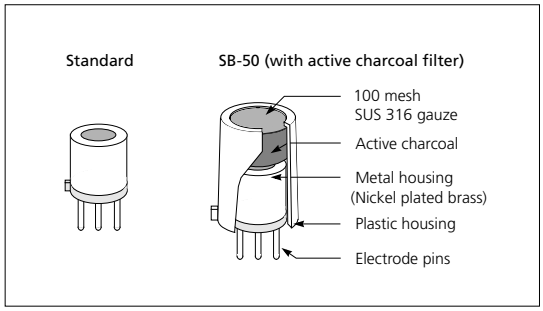


Fig 6. Configurations: standard housing and SB-50

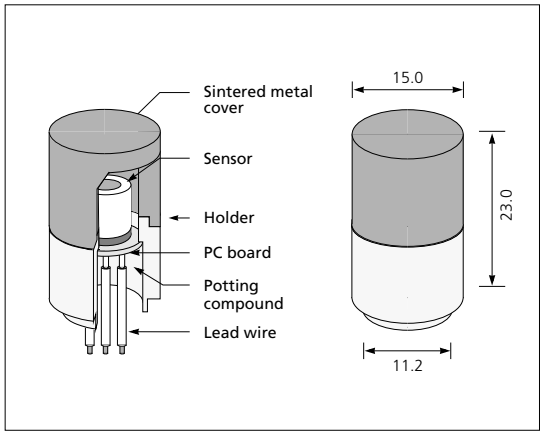


Fig 7. SB series with sintered metal housing

SB series

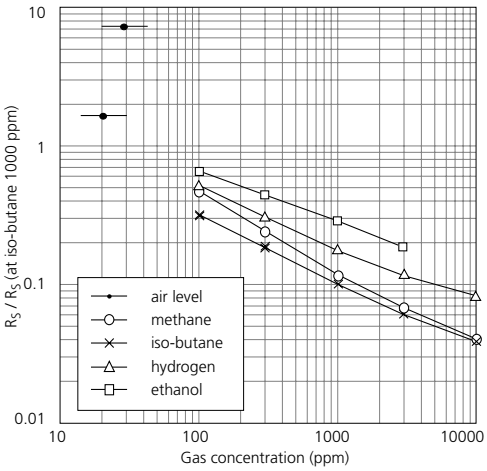


Fig 8. SB-11A for Hydrocarbons

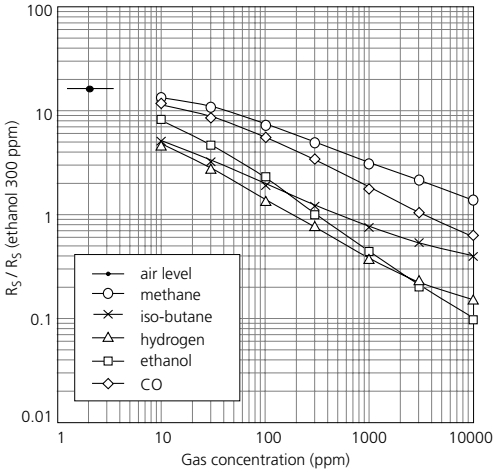


Fig 9. SB-31 for Solvents

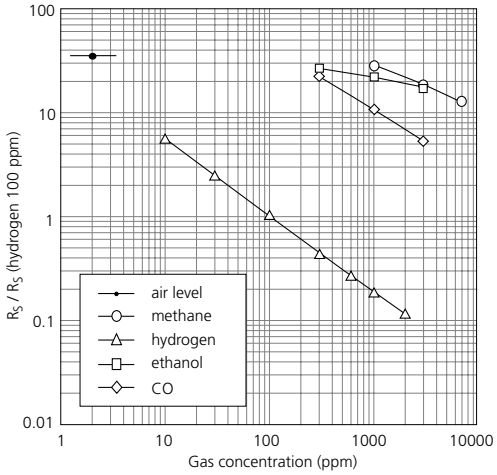


Fig 10. SB-19 for Hydrogen

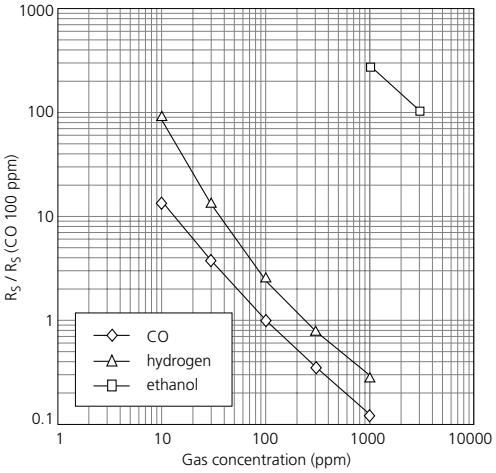


Fig 11. SB-50 for CO

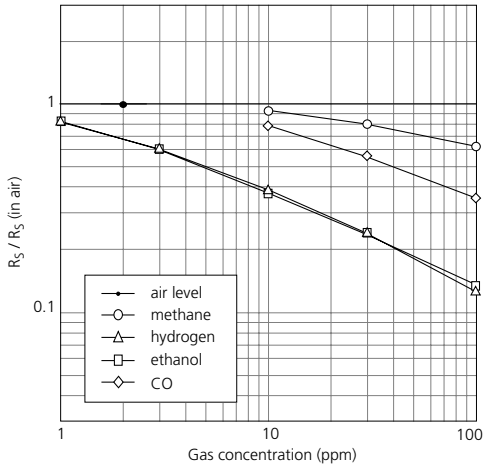


Fig 12. SB-AQ1 for Air Quality Controls (general)

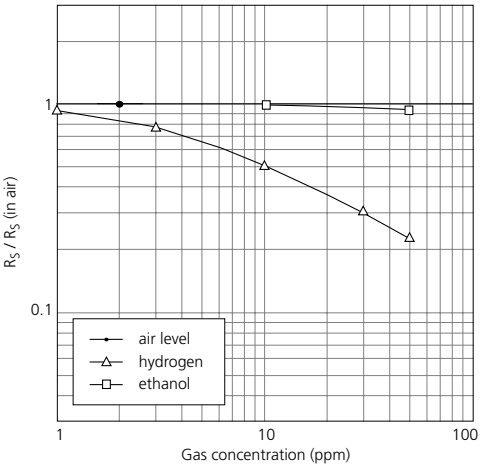


Fig 13. SB-AQ4 for Air Quality Controls (smoke)

New developments: SB series

SB-95: CO/methane sensor

Using both high and low sensor temperature in the periodic temperature change method (same operation method as the SB-50), it is possible to detect both CO and methane selectively with single element.

Fig 14 shows a typical temperature dependency characteristic of the SB-95. When the sensor is operated with high/low periodic operation (Fig 15), sensor signal changes according to the temperature dependency characteristics. By detecting the sensor signal at sufficient timings (at a high temperature for methane and at a low temperature for CO), selective detection of both methane and CO has been achieved. Figs 16 and 17 show the sensitivity characteristics of the SB-95, at high temperature and at low temperature signals respectively.

Using this concept, development of CO or methane, or both CO and methane detectors can be developed using the same sensor and circuit.

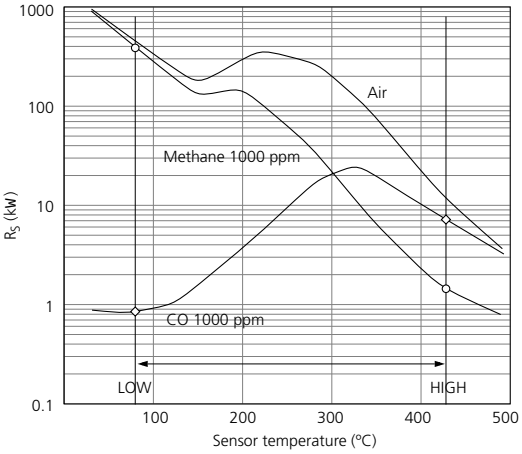


Fig 14. SB-95: Temperature dependency characteristics

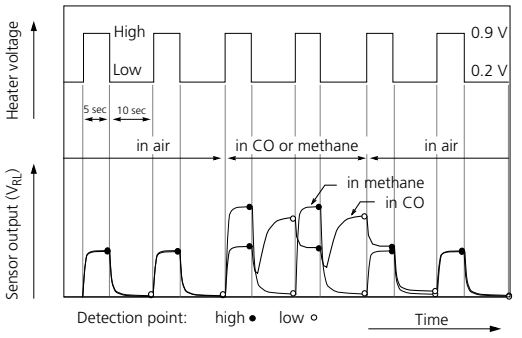


Fig 15. SB-95: Operating conditions and output signal

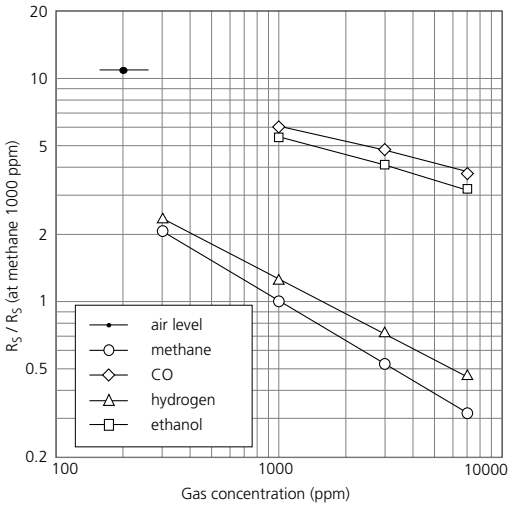


Fig 16. SB-95: Sensitivity at HIGH signal for methane

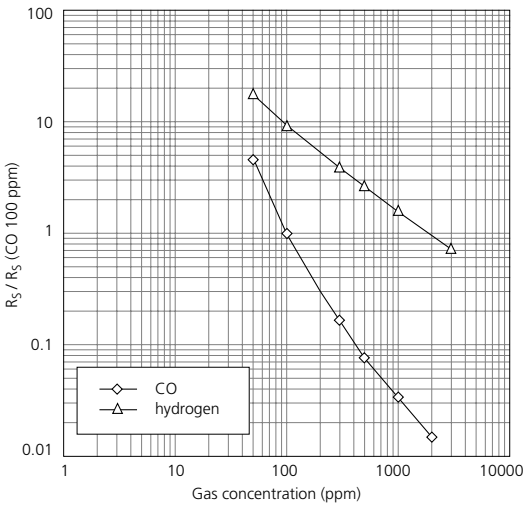


Fig 17. SB-95: Sensitivity at LOW signal for CO

SP series

General

The SP series was developed using an advanced thick film printing technology. By applying this technology on a small and thin ceramic substrate, a 50% reduction in current and power is achieved. Combinations of new design, variations of sensing materials and excellent controllability have lead to improvements in sensor performance and a wide variation in the product range.

Structure

The sensing material is formed on the alumina substrate on which the gold electrodes are printed. A thick film heater of ruthenium-oxide or platinum is printed on the reverse of the substrate (Fig 18).

The element is installed in the plastic or mesh type housing which uses a double stainless steel mesh (100 mesh) in the path of gas flow (Fig 19: standard type).

The sensor has four pins for output signal and heater power supply and one free pin for identification.

Operating conditions

Fig 20a indicates the pin layout and Fig 20b shows the equivalent circuit. The standard circuit for the SP series is shown in Fig 21.

The applied heater voltage regulates the sensing element temperature to obtain the specific performance of sensors. As in the SB series, the change in sensor resistance is obtained from the change in the output voltage across the fixed or variable load resistor (R_L).

Standard operating conditions:

V_C: 24 V max (DC/AC)
V_H: 5.0 V ± 4% (DC/AC)
R_L: Variable (P_S < 15 mW)
$P_S = (V_C - V_{RL})^2/R_S$

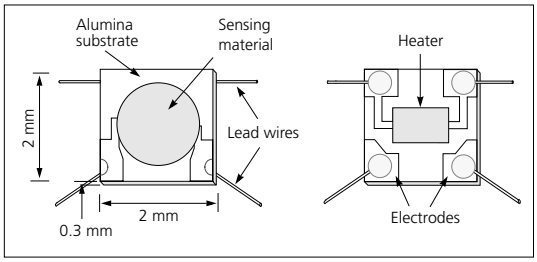


Fig 18. Sensing element

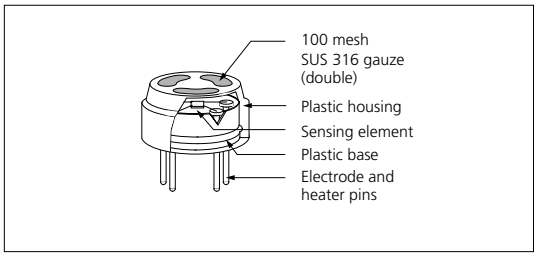


Fig 19. Structure: standard type (P1)

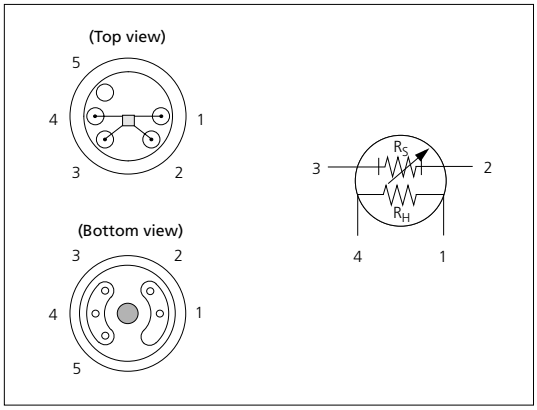


Fig 20a. Pin layout **Fig 20b. Equivalent circuit**

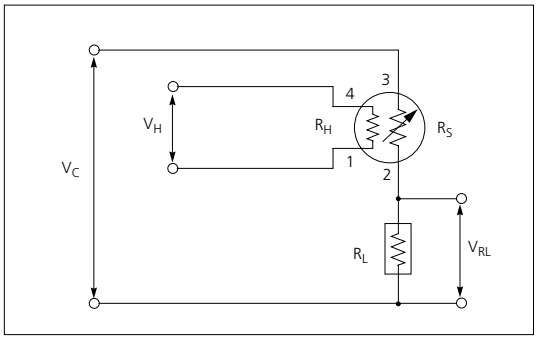


Fig 21. Standard circuit

Remarks:

Polarity of the circuit voltage (V_C) is not important.

SP series

Dimensions

Fig 22 shows the dimensions of the SP series (standard housing).

Configurations: variation of housing design

Fig 23 shows the variation of the SP (5 pin) configuration. Other variations of sensor pin layout and housing designs are available.

- Fig 24: a) SP3 type base (3 pin) with compact plastic housing
  b) SP4 type base (4 pin) with compact plastic housing
- Fig 25: Metal base (TO-39 type 4 pin)
- Fig 26: Metal base with a sintered metal external housing

Sensitivity characteristics (typical data)

Figs 27 to 38 on the following pages show the typical sensitivity characteristics data of SP series gas sensors. In these diagrams, the change in sensor resistance is normalized by the R_S at specific conditions.

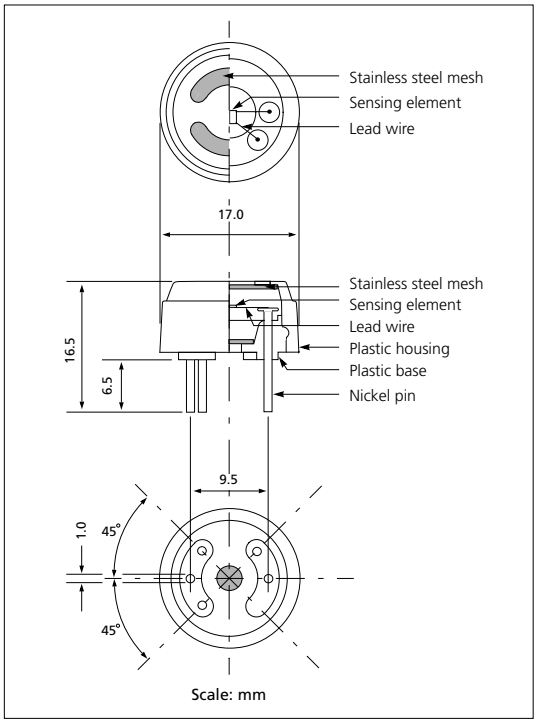


Fig 22. Dimensions: standard housing

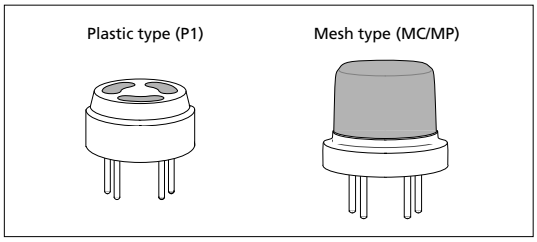


Fig 23. Configuration of sensor housing

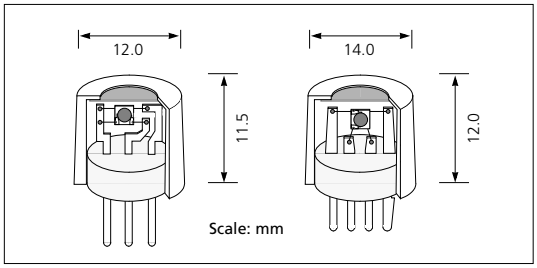


Fig 24. Compact plastic housing: SP3 (left) and SP4 (right)

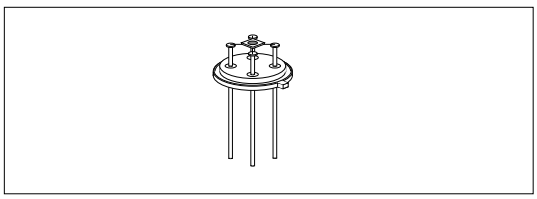


Fig 25. Metal base (TO-39 type 4 pin)

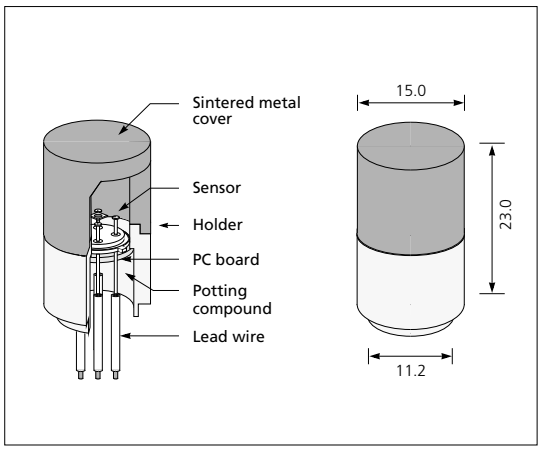


Fig 26. Sintered metal housing with metal base

SP series

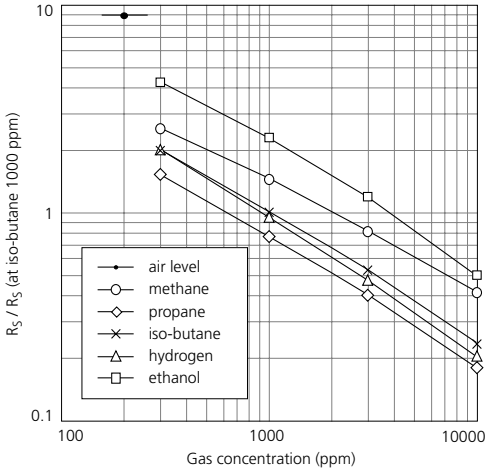


Fig 27. SP-11 for Hydrocarbons

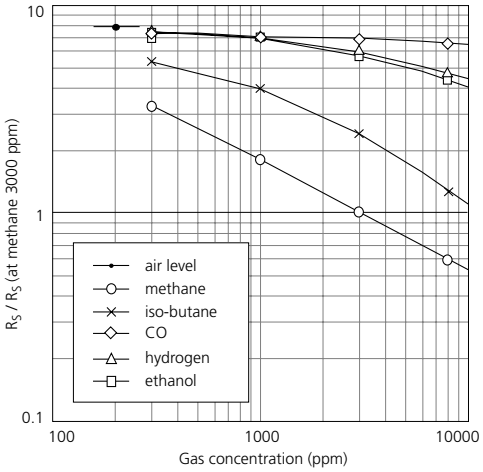


Fig 28. SP-12A for Methane (Natural gas)

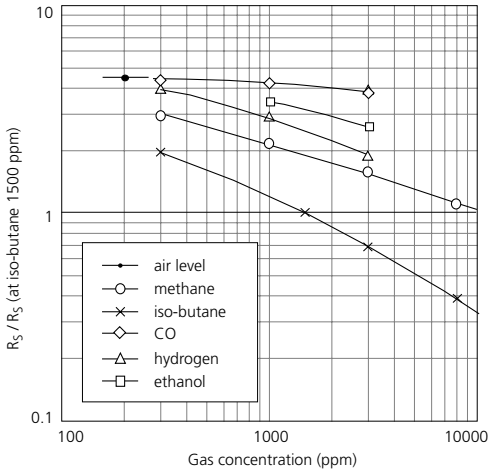


Fig 29. SP-15A for Propane/butane (LP-Gas)

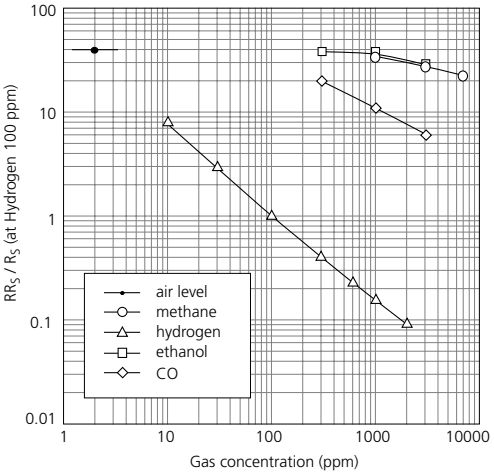


Fig 30. SP-19 for Hydrogen

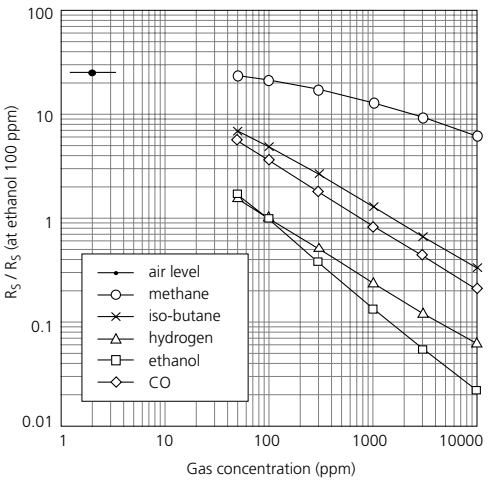


Fig 31. SP-31 for Solvents

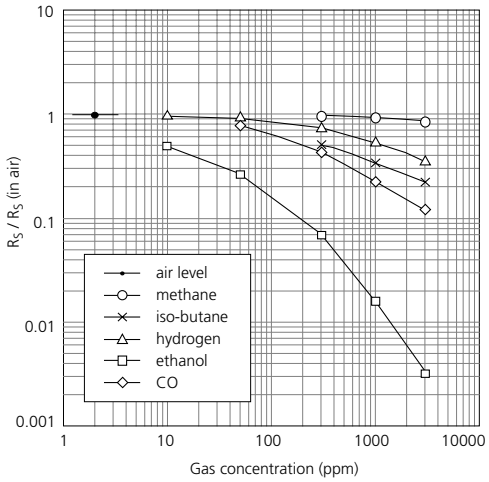


Fig 32. SP-32 for Alcohol

SP series

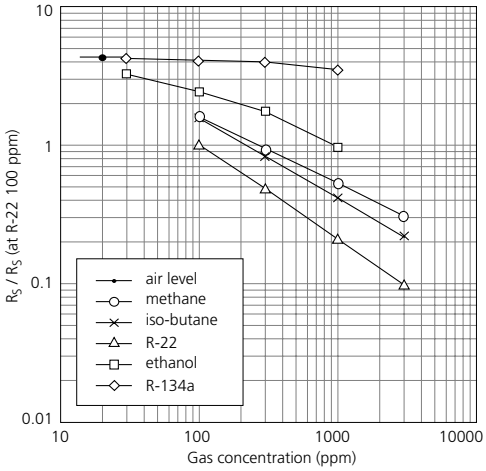


Fig 33. SP-41 for Freon (R-22)

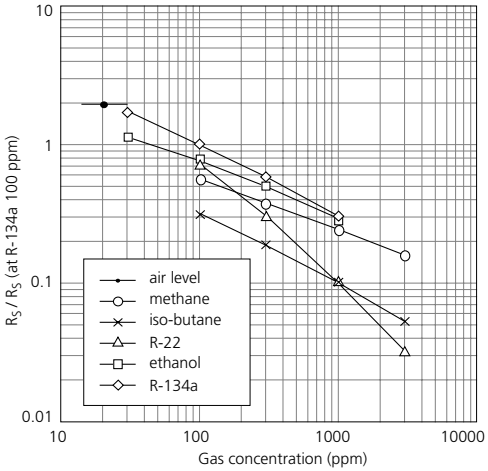


Fig 34. SP-42 for Freon (R-134a)

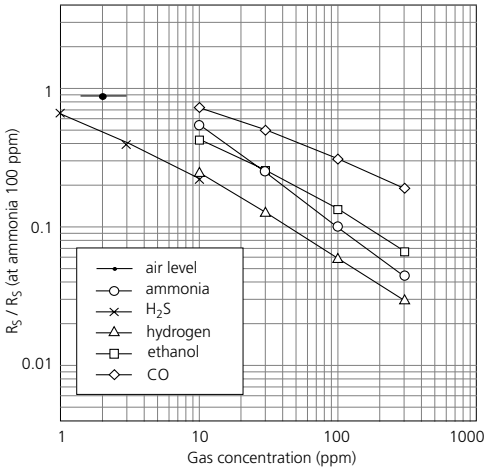


Fig 35. SP-53 for Ammonia

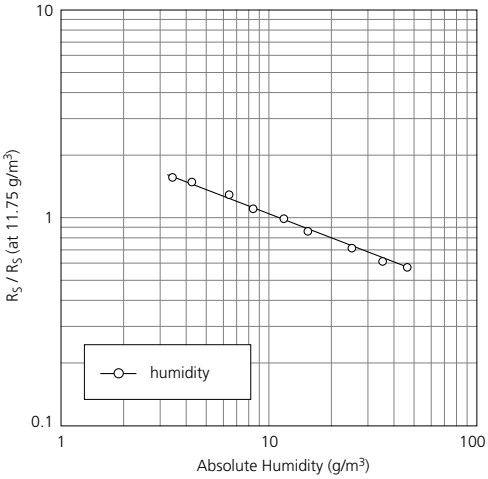


Fig 36. SP-MW1 for Cooking Controls (general)

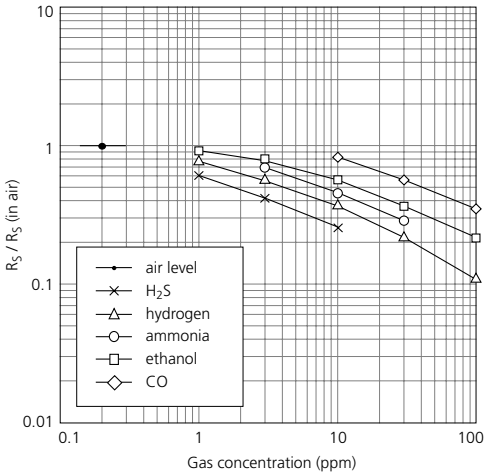


Fig 37. SP-AQ2 for Indoor Air Quality (general)

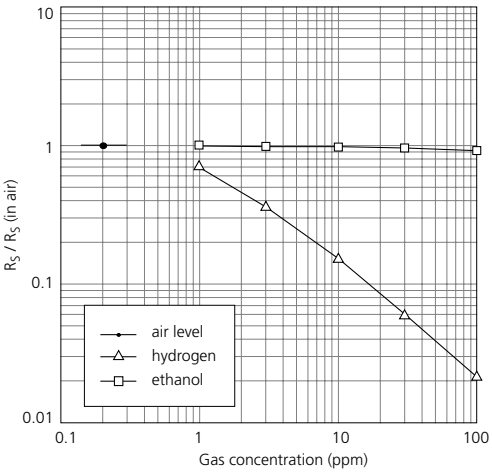


Fig 38. SP-AQ3 for Indoor Air Quality (smoke)

Related products

Microprocessors: IC- series

FIS develops specially designed microprocessors (microcomputers) for various applications such as indoor air quality controls, CO detection, domestic gas alarms, etc. Application of IC series enables efficient and economical solutions in the development of applied products.

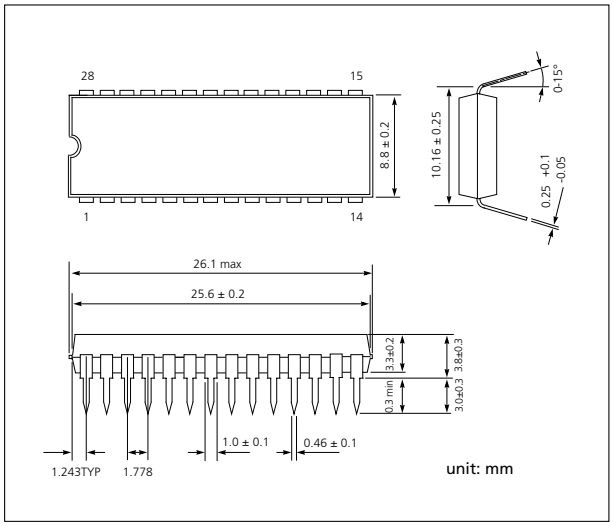


Fig 39. Standard compact plastic DIL package

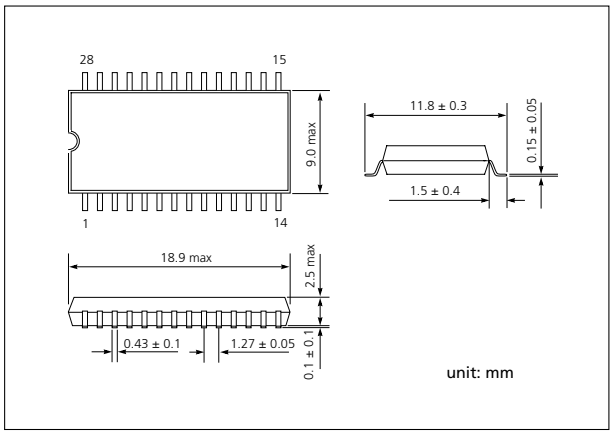


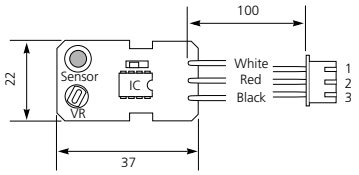
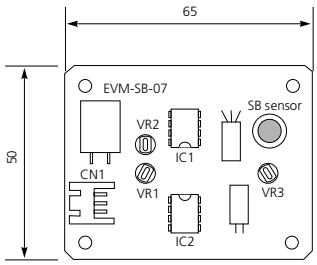
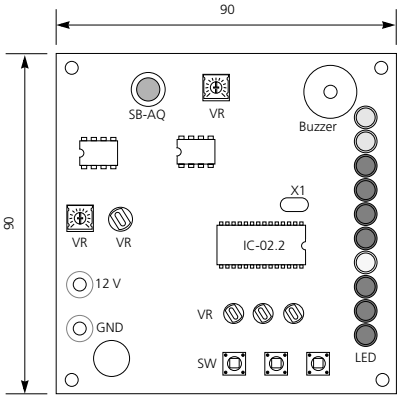
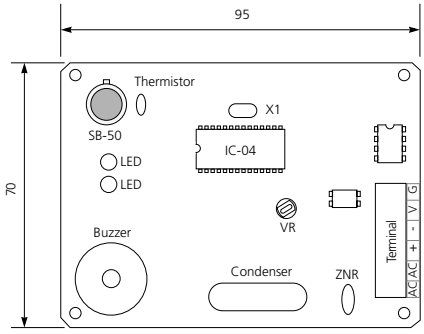
Fig 40. Flat package for SMD

Field	Model	Description	Features and functions
CO detection	IC-04-1 (OTP) IC-04-2.1 (OTP) IC-04-2.2 (EMC1004: SMD) OTP: One Time Processor	A series of microprocessors for driving the mini SB-50 sensor for reliability, low power, quick response and low cost CO detectors. These microprocessors include useful functions for CO alarm devices. Variations of functions and units are available with different versions. Standard product is the IC-04-2.2. with SMD type package.	• Heater power supply (Dynamic Driving method), signal detection (periodic sensor temperature change operation) • Alarm functions (including various options) • Temperature and humidity compensation • Memory function for calibration • Fail-safe signal, etc.
Domestic gas alarms	IC-05 (EMC6010: DIP) (EMC6020: SMD)	A microprocessor for domestic gas alarms for SP series including various functions which provide high reliability in flammable gas leak detection.	• Initial delay, alarm delay, temperature compensation, fail-safe and other functions

Modules

Evaluation modules: EVM series

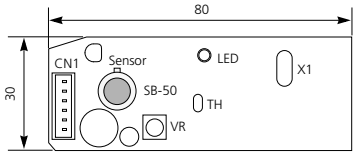
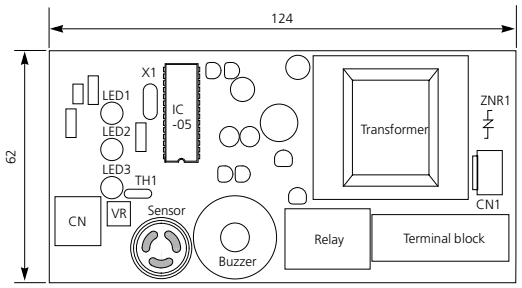
The EVM series includes modules with basic operation/detection circuits and/or examples of application circuits using FIS sensors and microprocessors.

Field	Model	Description and functions	Dimensions: Unit: mm, Scale: approx. 1/2
General purpose	**EVM-SB-01:** - SB series - SB-11 (for flammable gas detection)	Pre-calibrated module (e.g. at 10% LEL for flammable gas detection). Includes a standard driving circuit for evaluating the SB series gas sensor • Compact design • Low power consumption • 5 V DC input • V_{RL} output (0 - 4 V)	
	EVM-SB-07: - SB series	Module includes the 'Dynamic Driving' operation circuit for the SB series • Easy operation • Low power and low current • 5 V DC input • V_{RL} output	
Air quality controls (air purifiers)	**EVM-SB-02** - SB-AQ series + IC-02	Module includes driving circuit for the SB-AQ1 or SB-AQ4 and microprocessor IC-02 using 'Dynamic Driving' operation with low power consumption • Low power and low current • LED's indication and control signals for a fan (3 levels) • 12 V DC input (9 V battery operation is also possible) • Pre-calibrated • Auto/manual switch and a timer function	
CO detection	**EVM-SB-05** - SB-50 + IC-04	Module for evaluating the mini CO sensor SB-50 with microprocessor IC-04. Periodic sensor temperature change operation with 10 seconds cycle (High: 3 secs and Low: 7 secs). Low current consumption using a 'Dynamic Driving' operation method • Mains power operation with no transformer (220 V and 100 V versions) • Low power consumption of 60 mW. • Visual alarm, buzzer and output signals (alarm and sensor signal output)	

Modules

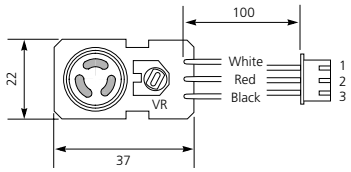
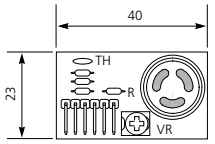
Example of applied products

Examples of commercial application designs are also available such as EVM-SB-08 and DGA-ES.

Field	Model	Description and functions	Dimensions: Unit: mm, Scale: approx. 1/2
CO detection	EVM-SB-08 - SB-50 + IC-04	Module for general purpose using the SB-50 with microprocessor IC-04. • Compact design • 5 V DC input • 2 level alarm signal output (for remote alarm), initial delay, fail-safe and other functions	
Flammable gas detection	DGA-ES: - SP-12A/SP-15 + IC-05	An example of domestic gas alarm (for natural gas or LP-Gas) using the SP-12A/SP-15 and IC-05 • Power supply: 100 V, 220 V AC or other conditions • With functions such as initial delay, alarm delay, temperature compensation, etc. • Natural gas (methane) and propane versions	

Pre-calibrated modules: PCM series

Combinations of sensors and small PCBs including fixed and variable resistors (R_L). These modules are calibrated at suitable conditions for indoor air quality or other applications and avoid calibration process in the assembly of applied products.

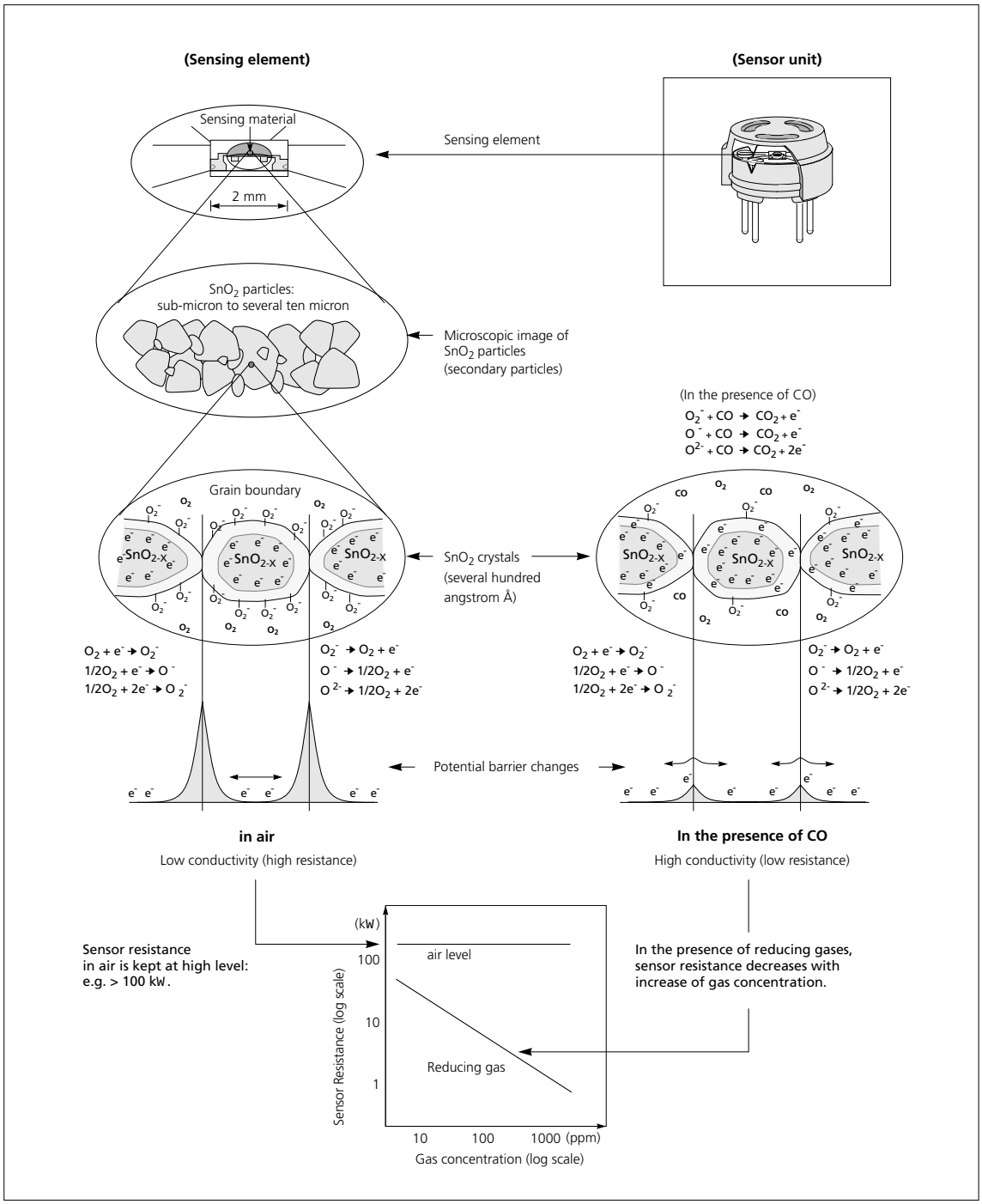
Field	Model	Description and functions	Dimensions: Unit: mm, Scale: approx. 1/2
Air quality controls	PCM-SP/ST-01 - SP-AQ series - ST-AQ series	Pre-adjusted sensor module for air quality controls • Sensor + PCB + cable • 5 V DC input • Output signal is specified by the sensitivity to hydrogen	
Flammable gas detection	PCM-SP-02 - SP-12A/SP-15	Pre-adjusted sensor module for methane or LP-Gas detection with temperature compensation • Sensor + PCB + terminal • 5 V DC input • Output signal is specified by the sensitivity to methane /LP-Gas	

Pre-classified sensor: PC version

Pre-classified sensors are supplied with code numbers showing sensor resistance level at specified conditions. Using this version, specific levels of output signal (V_{RL}) are obtained in the applied products. See SP-11/SP-12 User's Manual for details.

Metal oxide (SnO_2) semiconductor gas sensor

The conductivity of Tin dioxide (SnO_2) metal oxide semiconductor materials changes according to gas concentration changes. This is caused by adsorption/desorption of oxygen and reaction between surface oxygen and gases. These reactions cause a dynamic change of electric potential on SnO_2 crystal and results in the decrease of sensor resistance under the presence of reducing gases such as CO, methane, hydrogen. The figures below indicate the sensing mechanism of the SnO_2 gas sensor.



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